

Climate Change 1995: The IPCC Second Assessment Report

Scientific-Technical Analyses of Impacts,
Adaptations, and Mitigation of Climate Change

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*Contribution of Working Group II of the Intergovernmental Panel on Climate Change,
forming part of the IPCC Second Assessment Report*

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Contents

<i>Foreword</i>	v
<i>Preface</i>	vii
<i>Summary for Policymakers: Scientific-Technical Analyses of Impacts, Adaptations, and Mitigation of Climate Change</i>	1
<i>Technical Summary: Impacts, Adaptations, and Mitigation Options</i>	19
Part I—Introductory Materials	
A. Ecophysiological, Ecological, and Soil Processes in Terrestrial Ecosystems: A Primer on General Concepts and Relationships	57
B. Energy Primer	75
Part II—Assessment of Impacts and Adaptation Options	
1. Climate Change Impacts on Forests	95
2. Rangelands in a Changing Climate: Impacts, Adaptations, and Mitigation	131
3. Deserts in a Changing Climate: Impacts	159
4. Land Degradation and Desertification	171
5. Impacts of Climate Change on Mountain Regions	191
6. Non-Tidal Wetlands	215
7. The Cryosphere: Changes and Their Impacts	241
8. Oceans	267
9. Coastal Zones and Small Islands	289
10. Hydrology and Freshwater Ecology	325
11. Industry, Energy, and Transportation: Impacts and Adaptation	365
12. Human Settlements in a Changing Climate: Impacts and Adaptation	399
13. Agriculture in a Changing Climate: Impacts and Adaptation	427
14. Water Resources Management	469
15. Wood Production under Changing Climate and Land Use	487
16. Fisheries	511
17. Financial Services	539
18. Human Population Health	561
Part III—Assessment of Mitigation Options	
19. Energy Supply Mitigation Options	587
20. Industry	649
21. Mitigation Options in the Transportation Sector	679
22. Mitigation Options for Human Settlements	713
23. Agricultural Options for Mitigation of Greenhouse Gas Emissions	745
24. Management of Forests for Mitigation of Greenhouse Gas Emissions	773
25. Mitigation: Cross-Sectoral and Other Issues	799
Part IV—Technical Appendices	
26. Technical Guidelines for Assessing Climate Change Impacts and Adaptations	823
27. Methods for Assessment of Mitigation Options	835
28. Inventory of Technologies, Methods, and Practices	845
<i>Appendix A. Expert Reviewers of the IPCC Working Group II Volume</i>	853
<i>Appendix B. Glossary of Terms</i>	863
<i>Appendix C. Acronyms and Chemical Symbols</i>	873
<i>Appendix D. Units</i>	877
<i>Appendix E. List of Major IPCC Reports</i>	879

Foreword

The Intergovernmental Panel on Climate Change (IPCC) was jointly established by the World Meteorological Organization and the United Nations Environment Programme in 1988, in order to (i) assess available scientific information on climate change, (ii) assess the environmental and socioeconomic impacts of climate change, and (iii) formulate response strategies. The IPCC First Assessment Report was completed in August 1990, and served as the basis for negotiating the UN Framework Convention on Climate Change. The IPCC also completed its 1992 Supplement and “Climate Change 1994: Radiative Forcing of Climate Change and an Evaluation of the IPCC IS92 Emission Scenarios” to assist the Convention process further.

In 1992, the Panel reorganized its Working Groups II and III and committed itself to complete a Second Assessment in 1995, not only updating the information on the same range of topics as in the First Assessment, but also including the new subject area of technical issues related to the economic aspects of climate change. We applaud the IPCC for producing its Second Assessment Report (SAR) as scheduled. We are convinced that the SAR, as the earlier IPCC reports, would become a standard work of reference, widely used by policy-makers, scientists, and other experts.

This volume, which forms part of the SAR, has been produced by Working Group II of the IPCC, and focuses on potential impacts of climate change, adaptive responses, and measures that could mitigate future emissions. It consists of 25 chapters covering a wide range of ecological systems and socioeconomic sectors and activities. It also includes brief descriptions of three appendices—two sets of guidelines or methodologies for assessing the potential efficacy of adaptation and mitigation strategies, and an inventory of technology databases and information. The appendices themselves have been or are being published in full as separate stand-alone volumes.

As usual in the IPCC, success in producing this report has depended upon the enthusiasm and cooperation of numerous busy scientists and other experts world-wide. We are exceedingly pleased to note here the very special efforts implemented

by the IPCC in ensuring the participation of experts from the developing and transitional economy countries in its activities, in particular in the writing, reviewing, and revising of its reports. The experts have given of their time very generously, and governments have supported them in the enormous intellectual and physical effort required, often going substantially beyond reasonable demands of duty. Without such conscientious and professional involvement, the IPCC would be greatly impoverished. We express to all these experts, and the governments who supported them, our grateful and sincere appreciation for their commitment.

We take this opportunity to express our gratitude for nurturing another IPCC report through to a successful completion to:

- Professor Bolin, Chairman of the IPCC, for his able leadership and skillful guidance of the IPCC
- The Co-Chairs of Working Group II, Dr. R.T. Watson (USA) and Dr. M.C. Zinyowera (Zimbabwe)
- The Vice-Chairs of the Working Group, Dr. M. Beniston (Switzerland), Dr. O. Canziani (Argentina), Dr. J. Friaa (Tunisia), Ing. (Mrs.) M. Perdomo (Venezuela), Dr. M. Petit (France), Dr. S.K. Sharma (India), Mr. H. Tsukamoto (Japan), and Professor P. Vellinga (The Netherlands)
- Dr. R.H. Moss, the Head of the Technical Support Unit of the Working Group, and his staff including Mr. David Jon Dokken, Ms. Flo Ormond, Ms. Sandy MacCracken, and Ms. Laura VanWie, as well as Mr. Shardul Agrawala, Ms. Melissa Taylor, and Ms. Anne Tenney, who served as interns for various periods with the Technical Support Unit
- Dr. N. Sundararaman, Secretary of the IPCC, and his staff including Mr. S. Tewungwa, Mrs. R. Bourgeois, Ms. C. Ettori, and Ms. C. Tanikie.

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Secretary-General
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Preface

In June 1993, Working Group II of the Intergovernmental Panel on Climate Change (IPCC) was asked to review the state of knowledge concerning the impacts of climate change on physical and ecological systems, human health, and socio-economic sectors. Working Group II also was charged with reviewing available information on the technical and economic feasibility of a range of potential adaptation and mitigation strategies.

This volume responds to this charge and represents a tremendous achievement—the coordinated contributions of well over a thousand individuals from over 50 developed and developing countries and a dozen international organizations. It includes introductory “primers” on ecological systems and energy production and use; 25 chapters, covering both vulnerability to climate change and options for reducing emissions or enhancing sinks; and three appendices that inventory mitigation technologies and delineate methodologies for assessing impacts/adaptations and mitigation options.

The chapters provide an overview of developments in our scientific understanding since the first IPCC assessments of impacts and response options in 1990, and the supplemental IPCC assessments of 1992. Uncertainties are described, with an eye for identifying both policy significance and research opportunities. In presenting this information, each team of authors has sought to communicate its findings in way that is useful to decisionmakers, research managers, and peers within their field of research; we hope that these audiences, in addition to educators and the general public, will find this volume useful.

Approach of the Assessment

From the earliest stages of the process, participants in the assessment understood the need to confront the fact that confidence in regional projections of temperature, precipitation, soil moisture, and other climate parameters important to impacts models remains low, that uncertainty increases as scale decreases, that patterns of climate change are interwoven with climate variability, and that regional patterns are likely to be affected by both greenhouse gases and anthropogenic aerosols, the latter of which are only now beginning to be incorporated into transient GCM simulations. To provide useful information to decisionmakers, Working Group II needed to find a way to distinguish between uncertainties arising from remaining questions about the responses of systems to a given level or rate of climate change and uncertainties related to the regional-scale climate projections themselves. Consequently, Working Group II decided to focus on *assessing the sensitivity and vulnerability of systems* to a range of climate changes, and only then, having

identified response functions and/or potential thresholds, on *evaluating the plausible impacts* that would result from a particular regional climate scenario. In essence, the approach first sought to clarify what was known and unknown about three distinct issues before applying regional climate scenarios to estimate potential impacts. These issues were:

- How *sensitive* is a particular system to climate change—that is, in simplified terms, how will a system respond to given changes in climate? Given the wide range of systems reviewed in this assessment, these relationships are described in a variety of forms, ranging from specification of quantitative functional relationships for some systems (e.g., climate-yield models for agriculture, rainfall-runoff models for hydrological systems, models of energy demand for heating or cooling driven by temperature change) to more qualitative relationships for other systems.
- How *adaptable* is a particular system to climate change—that is, to what degree are adjustments possible in practices, processes, or structures of systems in response to projected or actual changes of climate? This issue is important for both ecological and social systems because it is critical to recognize that both types of systems have capacities that will enable them to resist adverse consequences of new conditions or to capitalize on new opportunities. Adaptation can be spontaneous or planned, and can be carried out in response to or in anticipation of changes.
- Finally, how *vulnerable* is a system to climate change—that is, how susceptible is it to damage or harm? Vulnerability defines the extent to which climate change may damage or harm a system. It depends not only on a system’s sensitivity but also on its ability to adapt to new climate conditions. Both the magnitude and rate of climate change are important in determining the sensitivity, adaptability, and vulnerability of a system.

Building on this sensitivity/vulnerability approach, the chapters of the assessment distinguish, to the extent possible, uncertainties relating to remaining questions about the sensitivity, adaptability, or vulnerability of systems to climate change from uncertainties related to the particular regional climate scenarios used in their estimation of potential impacts.

Levels of Confidence

In the course of the assessment, Working Group II also developed a common approach to describe the levels of confidence that author teams were asked to assign to the major findings in

the executive summaries of their chapters. Several approaches were considered, and the lead authors finally selected a straight-forward, three-tiered structure:

- *High Confidence*—This category denotes wide agreement, based on multiple findings through multiple lines of investigation. In other words, there was a high degree of consensus among the authors based on the existence of substantial evidence in support of the conclusion.
- *Medium Confidence*—This category indicates that there is a consensus, but not a strong one, in support of the conclusion. This ranking could be applied to a situation in which an hypothesis or conclusion is supported by a fair amount of information, but not a sufficient amount to convince all participating authors, or where other less plausible hypotheses cannot yet be completely ruled out.
- *Low Confidence*—This category is reserved for cases when lead authors were highly uncertain about a particular conclusion. This uncertainty could be a reflection of a lack of consensus or the existence of serious competing hypotheses, each with adherents and evidence to support their positions. Alternatively, this ranking could result from the existence of extremely limited information to support an initial plausible idea or hypothesis.

Readers of the assessment need to keep in mind that while the confidence levels used in the report are an attempt to communicate to decisionmakers a rough sense of the collective judgment by the authors of the degree of certainty or uncertainty that should be associated with a particular finding, they are an imperfect tool. In particular, it should be noted that assigning levels of confidence to research findings is a subjective process; different individuals will assign different levels of confidence to the same findings and the same base of evidence

because they demand different standards of proof. Moreover, there are multiple sources of uncertainty, some of which are difficult to identify with precision, leading different individuals to make different judgments. Finally, the amount of evidence that an individual will require to view a finding as “well-established” has been shown to be higher for findings that have high consequence than for findings of lesser consequence or for which less is at stake.

Acknowledgments

We wish to acknowledge the tireless, voluntary efforts of authors, contributors, and reviewers (from universities, private and government laboratories, and industry and environmental organizations). We wish to thank the following talented and dedicated individuals who served as staff, interns, or volunteers at the Working Group II Technical Support Unit during portions of this assessment: Mr. Shardul Agrawala, Mr. David Jon Dokken, Mr. Steve Greco, Ms. Dottie Hagag, Ms. Sandy MacCracken, Ms. Flo Ormond, Ms. Melissa Taylor, Ms. Anne Tenney, and Ms. Laura Van Wie. Without the willingness of all these individuals to give unstintingly of their professional expertise and free time, this assessment would not have been possible. We acknowledge the critical role of many program managers in national and international research programs who supported the work of the authors through grants and release time from other responsibilities. We also note that the volume benefitted greatly from the close working relationship established with the authors and Technical Support Units of Working Groups I and III. Last, but certainly not least, we wish to acknowledge the leadership of the IPCC Chairman, Professor Bert Bolin, and the IPCC Secretary, Dr. N. Sundararaman.

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